## Status of Climate Modeling at NCAR

# The Community Climate System Model

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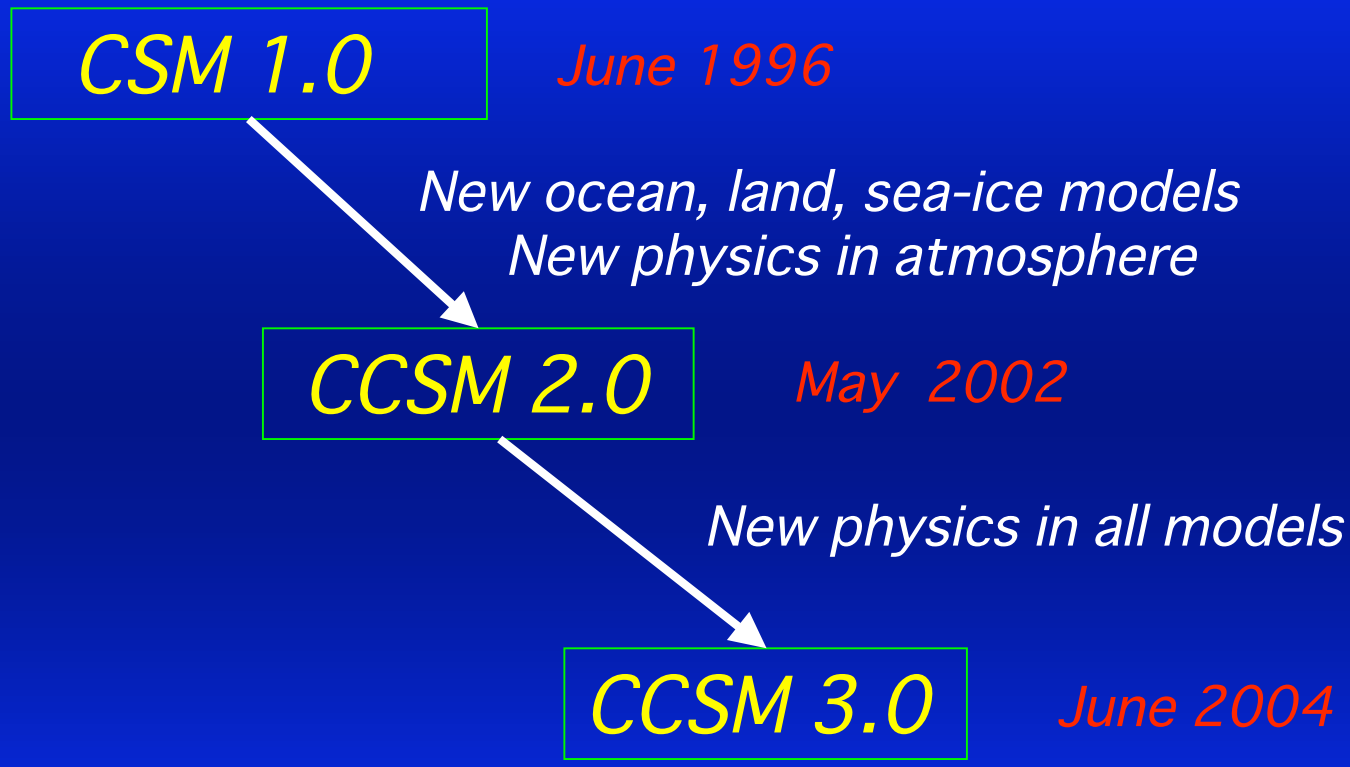
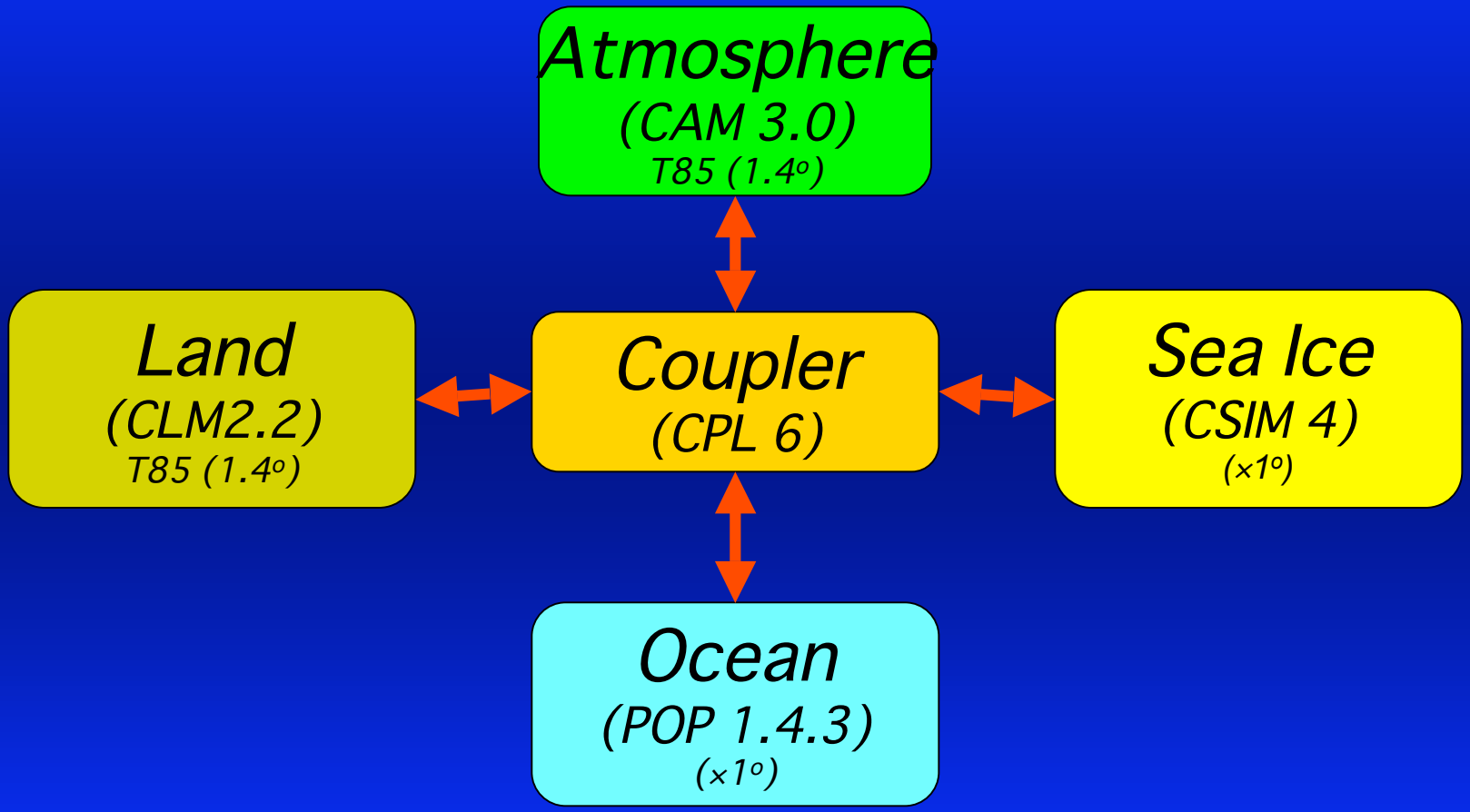
- Configuration of CCSM3
- Improvements in the physical formulation
- Distribution and interaction with climate community
- Application to IPCC
- The near-term future of CCSM

# Development History of CCSM



# Configuration of CCSM for IPCC

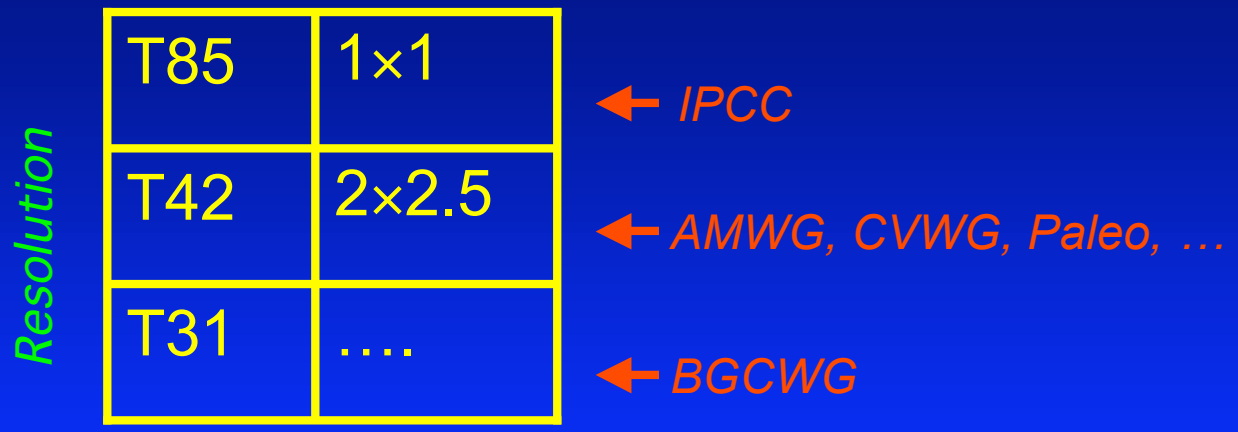


# Component Models in CCSM

- Atmosphere
  - Multiple dynamical cores: SLD, Eulerian, & Finite Volume
  - Generalized 2D decomposition of grid
  - Resolutions with most heritage: T31, T42, and T85 (L26)
- Ocean
  - Derivative of LANL Parallel Ocean Program
  - Grid: spherical in S. hemisphere, orthogonal curvilinear in N. hemisphere
  - Standard resolution: 320 x 384 (L40)
- Land Surface
  - Superset of NCAR LSM and Georgia Tech BATS
  - Same horizontal resolution as atmosphere
  - 10 layers for soil, up to 5 for snowpack
- Sea Ice
  - Up to 5 categories of sea-ice thickness

# Atmospheric Dynamics and Resolution

- Goal for IPCC: T85 (1.4°) or equivalent FV resolution
  - Improved resolution for regional impact studies
  - Improved resolution for fidelity in coastal stratus regions
- Recommendation on atmospheric dynamics:
  - Eulerian for standard IPCC scenario applications
  - Finite Volume for future development and experimentation
- Goal for CCSM: Single physics package for multiple dynamics & resolutions:



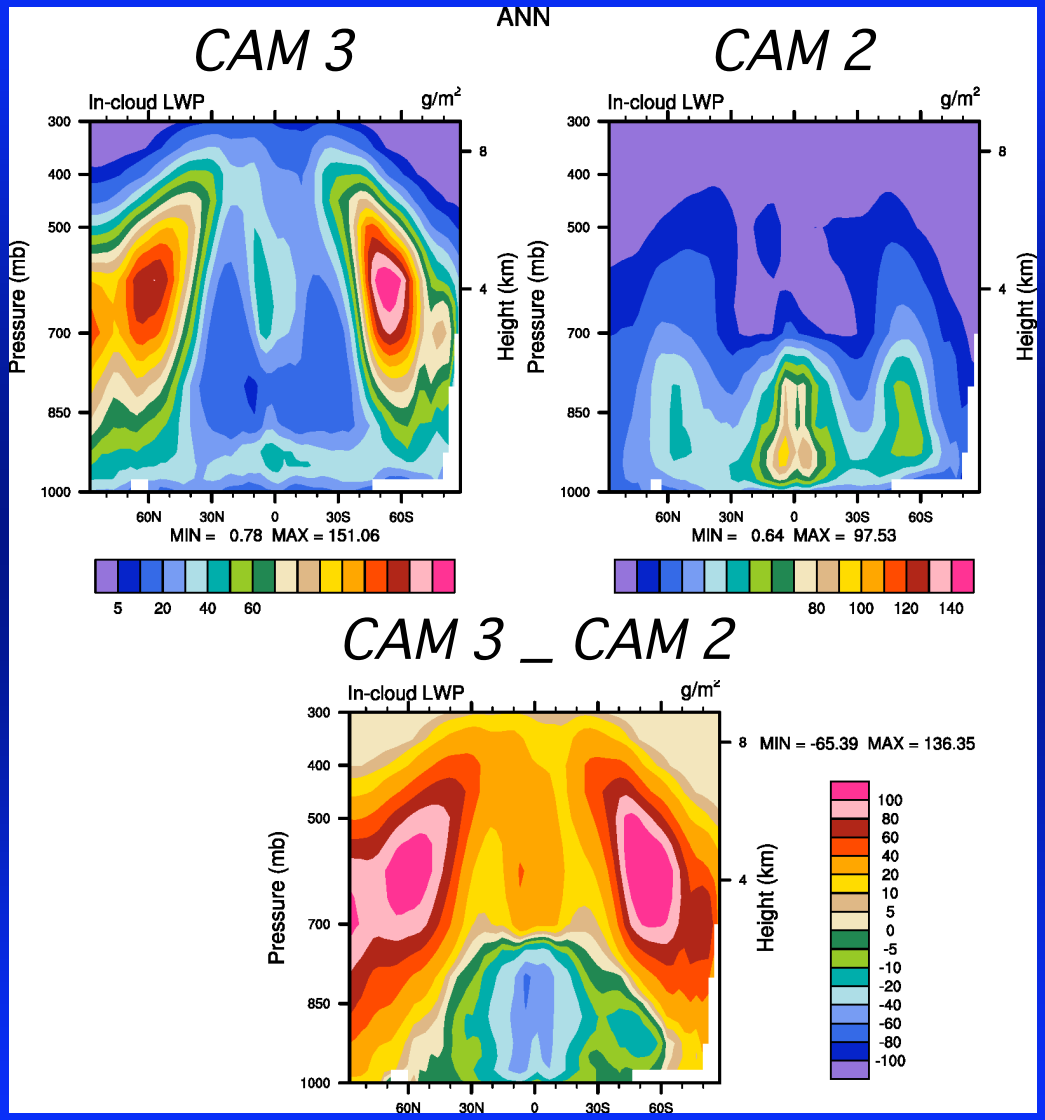
# Technical Infrastructure

- Portability: CCSM is designed to run on
  - IBM SP
  - HP Compaq
  - SGI Origin and Altix systems
  - Linux clusters
  - NEC and Cray vector systems
- Flexibility:
  Earth System Modeling Framework (ESMF)
- Simplicity:
  Abstracted coupling between physics & dynamics

# Changes to Physics in CAM3

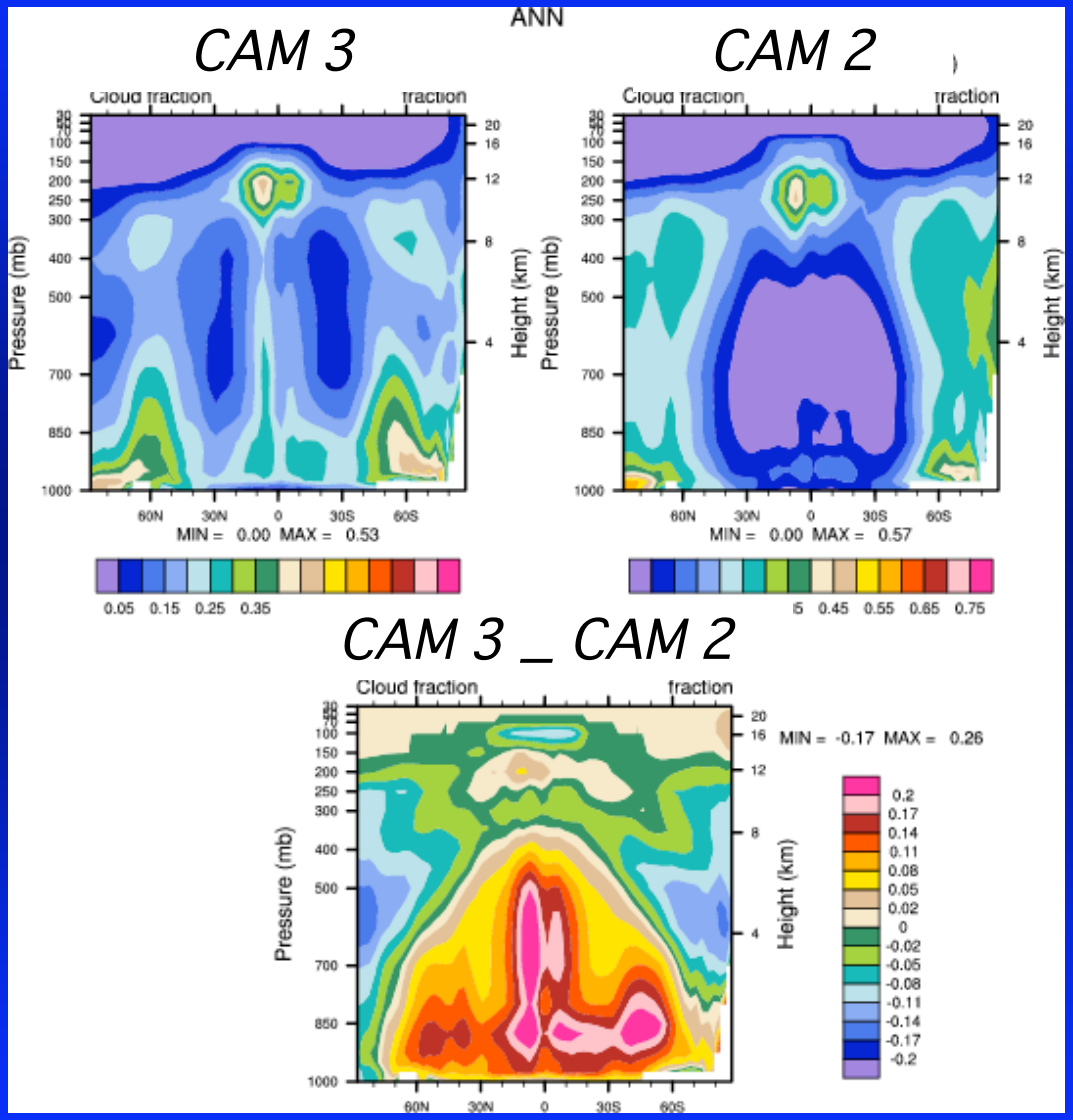
- Clouds and condensate:
  - Improved prognostic cloud water & moist processes
  - Transfer of mixed phase precipitation to land surface
  - Improved cloud parameterization
- Radiation:
  - Shortwave forcing by diagnostic aerosols
  - Updated SW scheme for H2O absorption
  - Updated LW scheme for LW absorption and emission
- Surface models:
  - Introduction of CLM 2.2
  - Reintroduction of Slab Ocean Model (SOM)
- Energy fixers for dynamics + diagnostics

# Increased Cloud Condensate




- *Separate cloud liquid and ice variables*
- *Advect cloud condensate*
- *Include latent heat of fusion*
- *Use ice & water variables for cloud optics*
- *New dependence on temperature for cirrus particle size*
- *Sedimentation of cloud droplets and ice particles*
- *Modified evaporation of rain*

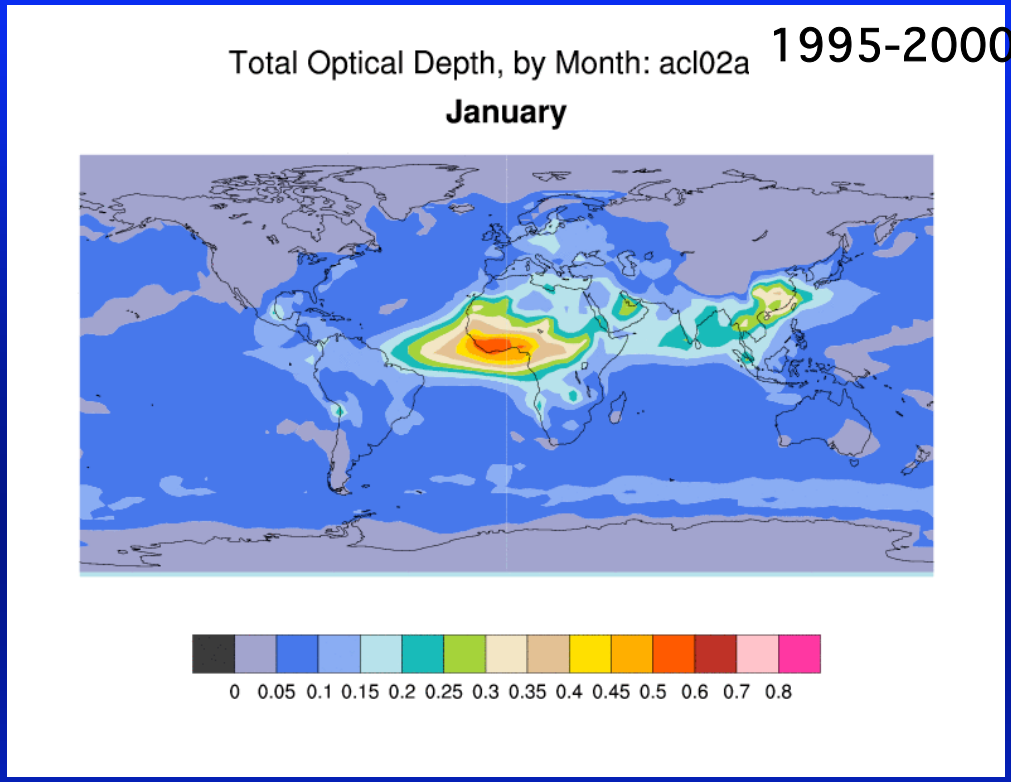
# Increased Cloud Amounts




- *PBL height constrained*
- *Rain rate ≥ 0*
- *Convection cloud amounts from convective mass fluxes*
- *Stratocumulus clouds in lowest 2 levels*
- *Changes to autoconversion thresholds*
- *Changes to relative humidity thresholds*
- *Fall speed of droplets is function of effective radius*

$$\Delta NET_{TOA} = -4.5\ Wm^{-2}$$
$$NET_{TOA} = 0.53\ Wm^{-2}$$

# Global Aerosol Assimilation Climatology




AVHRR

Analysis

Aerosol Assimilation

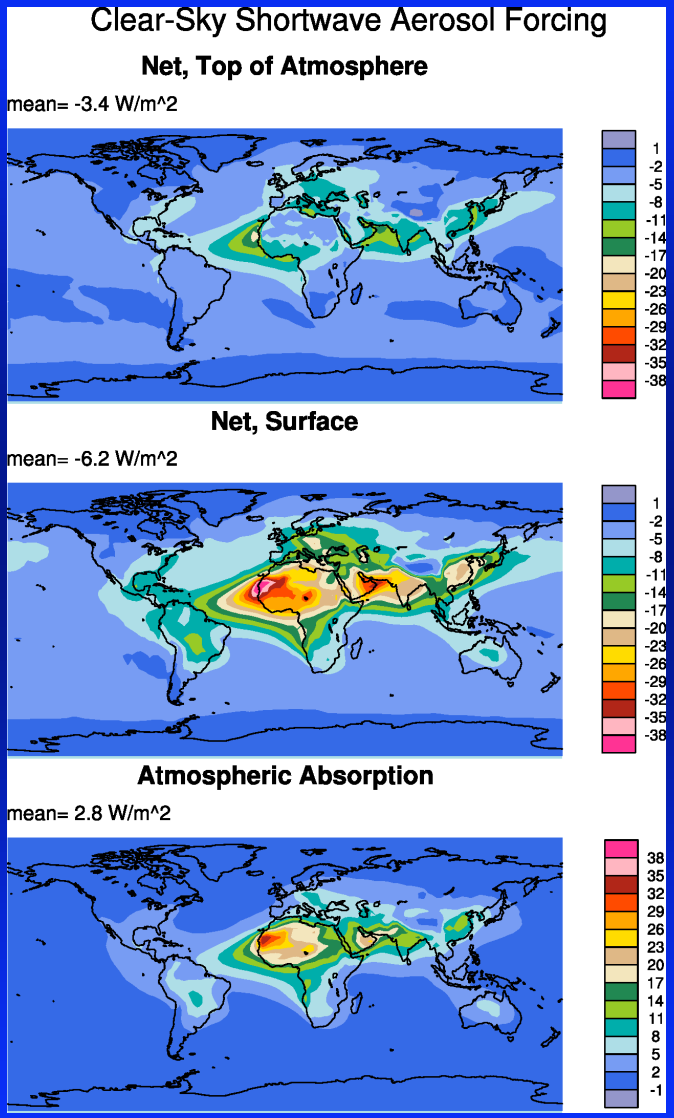
NCAR CAM

Analysis

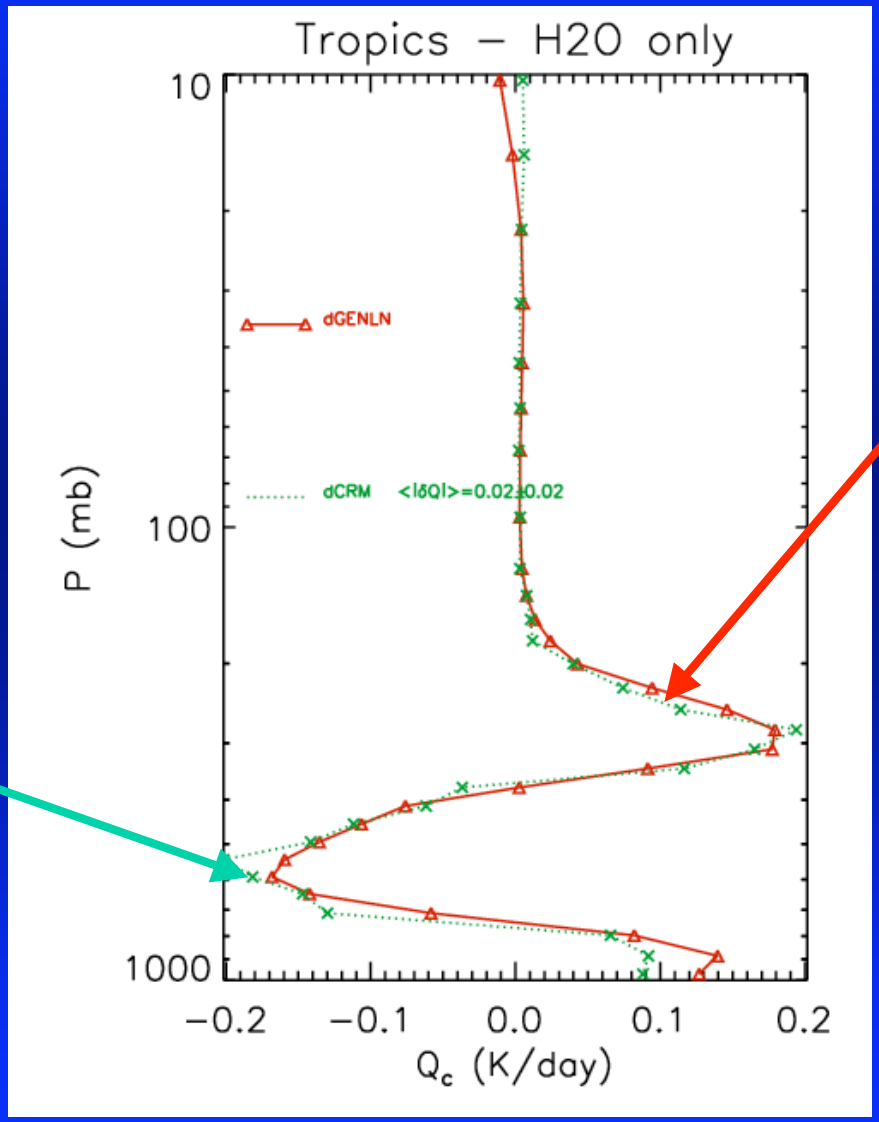
Aerosol Forcing

Climate Impacts

# Addition of Prescribed Aerosol Forcing



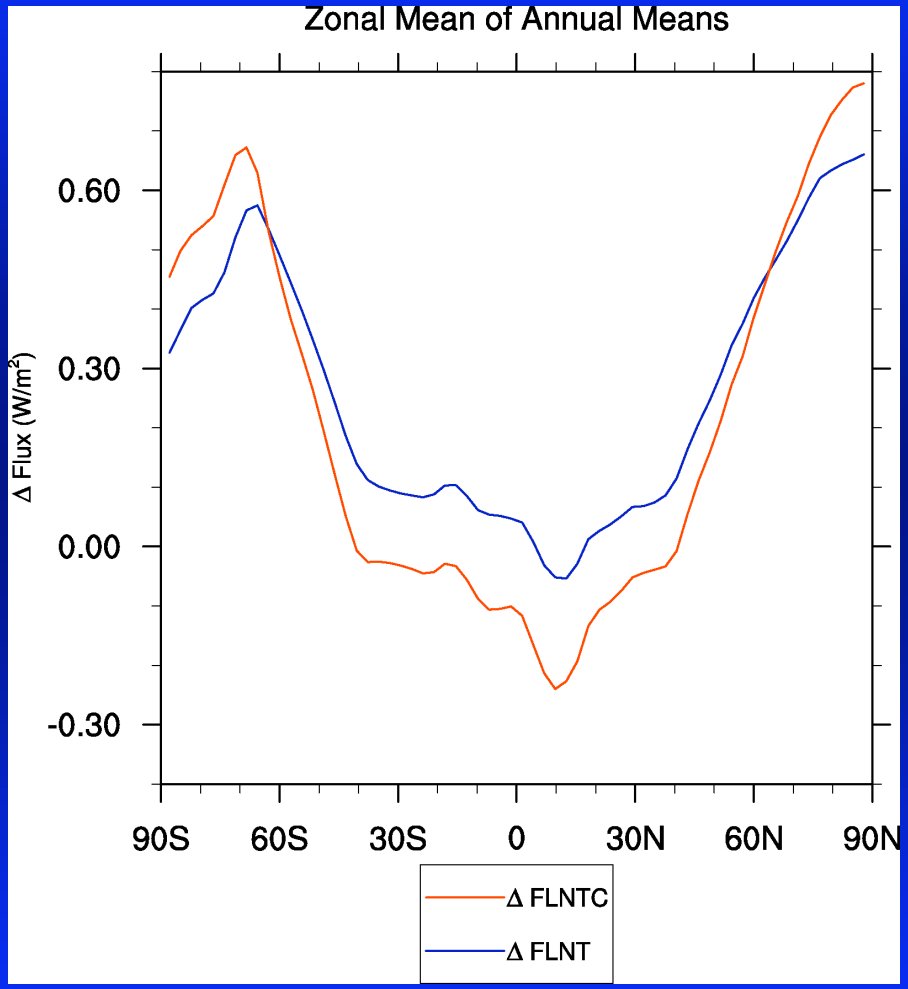
# Changes in Longwave Cooling Rates:
## New H2O Lines and Continuum

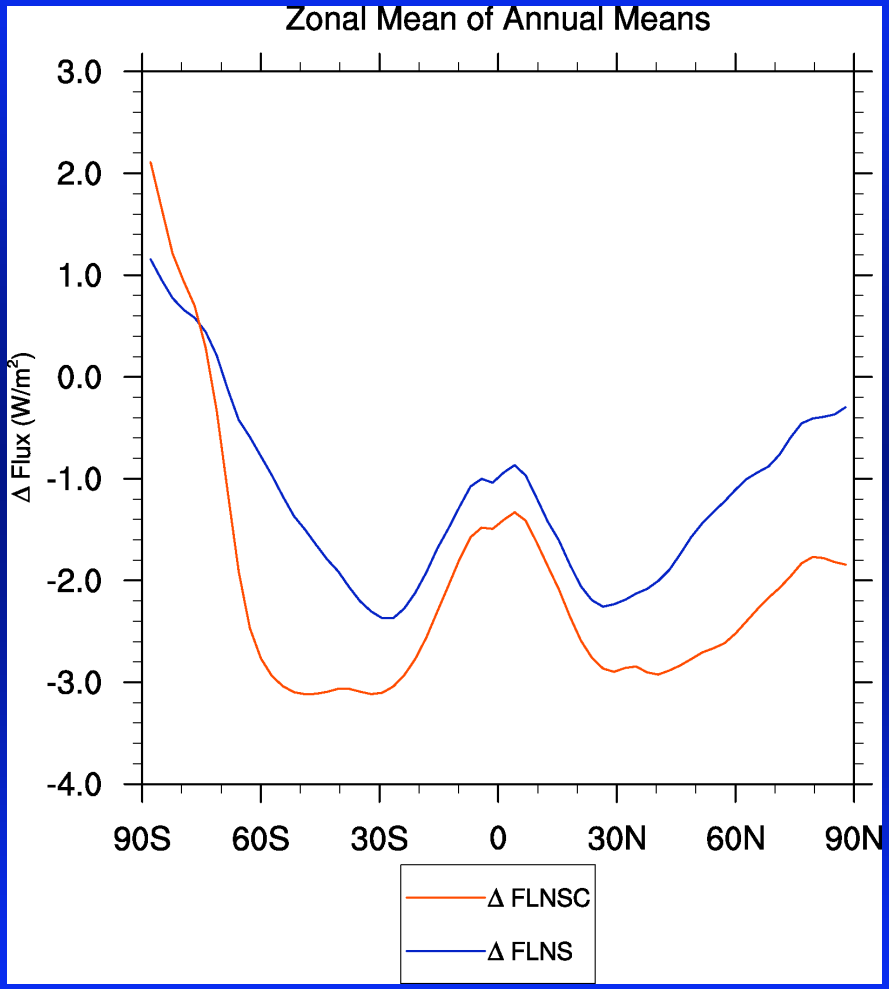



*Change in LBL Cooling*

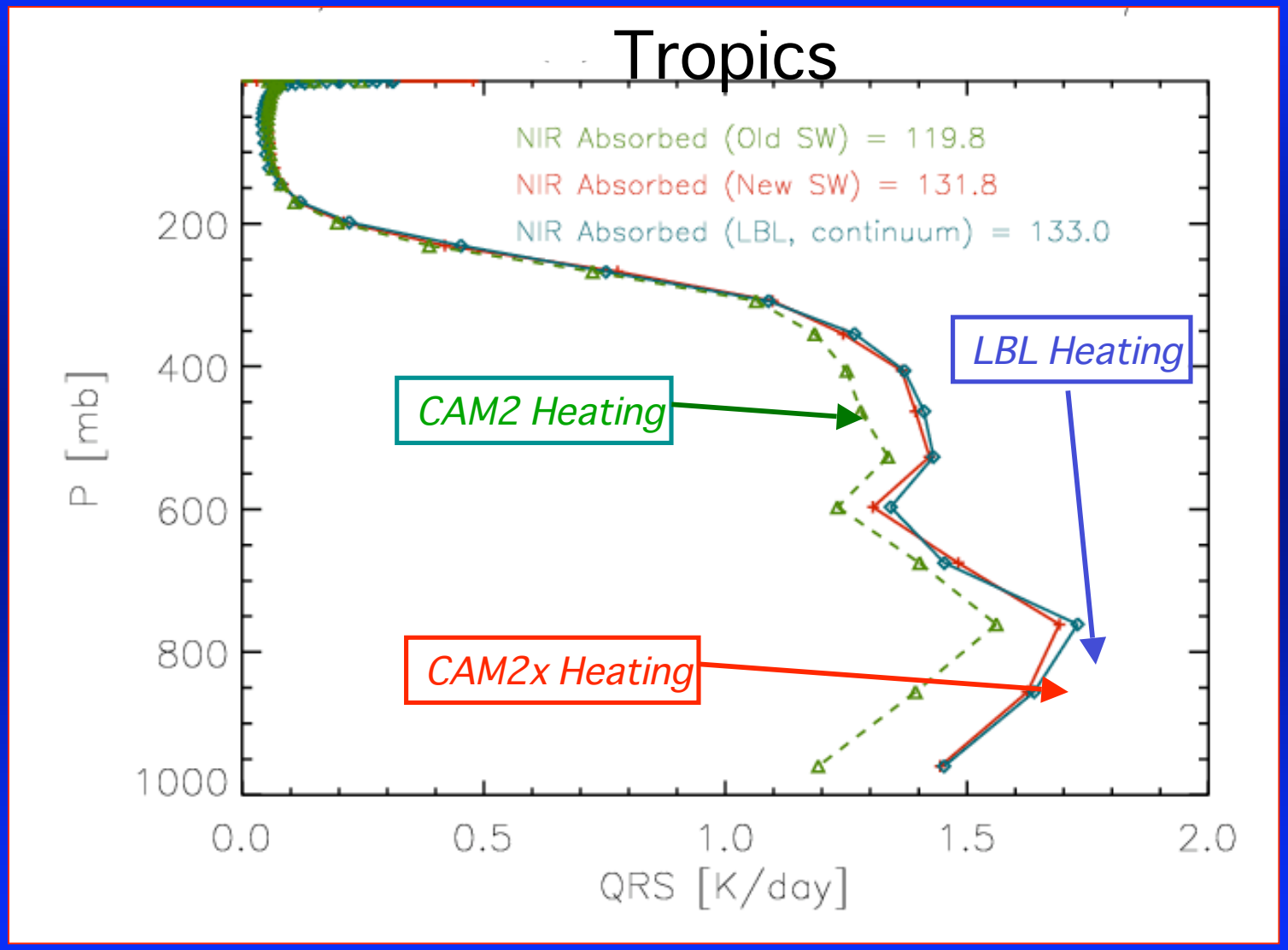
*Change in CAM Cooling*

# Global Decrease in Longwave Fluxes

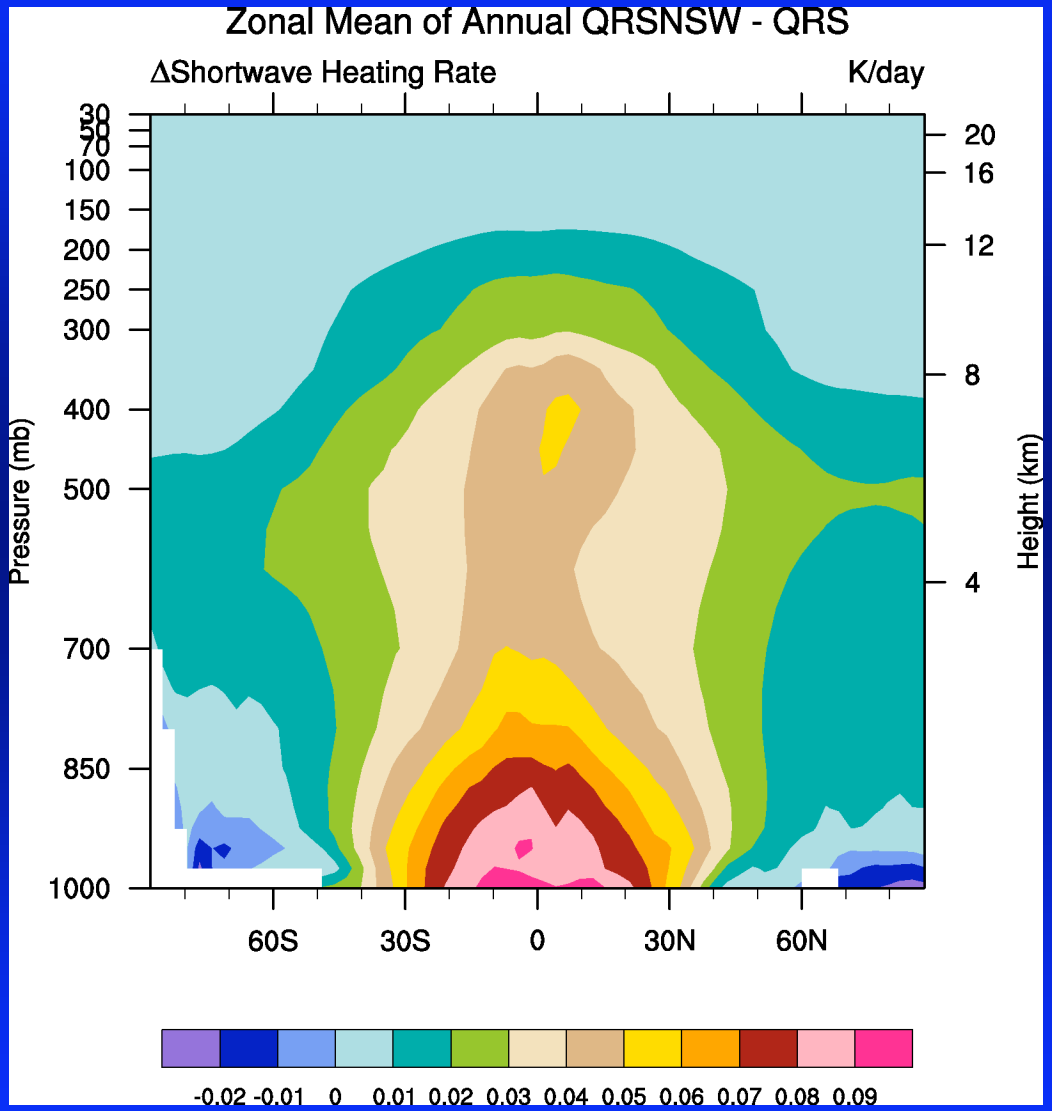


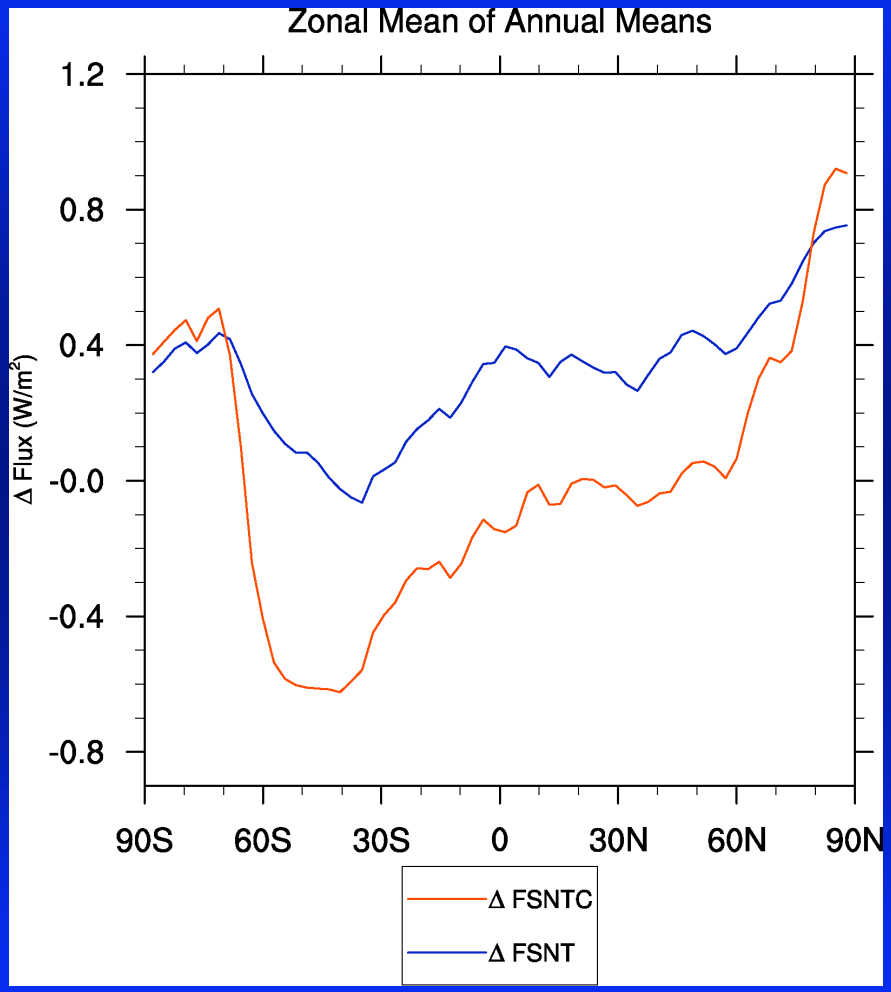
# Changes in Shortwave Heating Rates:
## New H2O Lines and Continuum

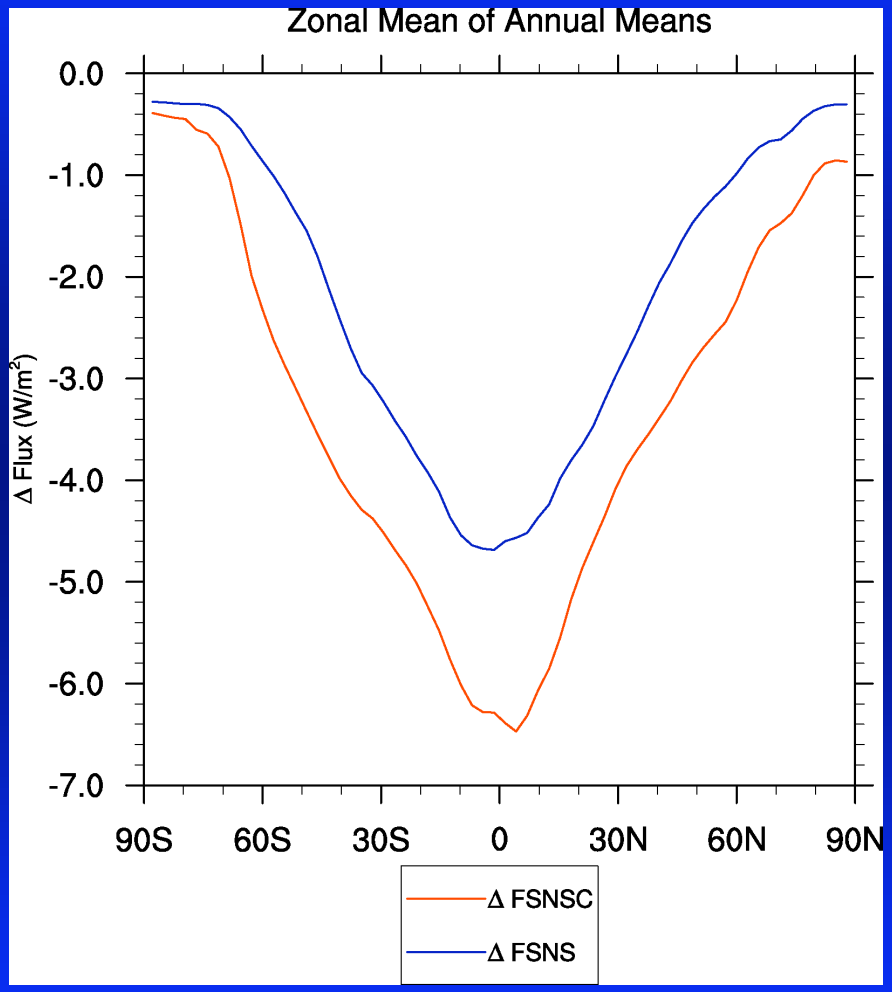


# Global Increase in SW Heating Rates

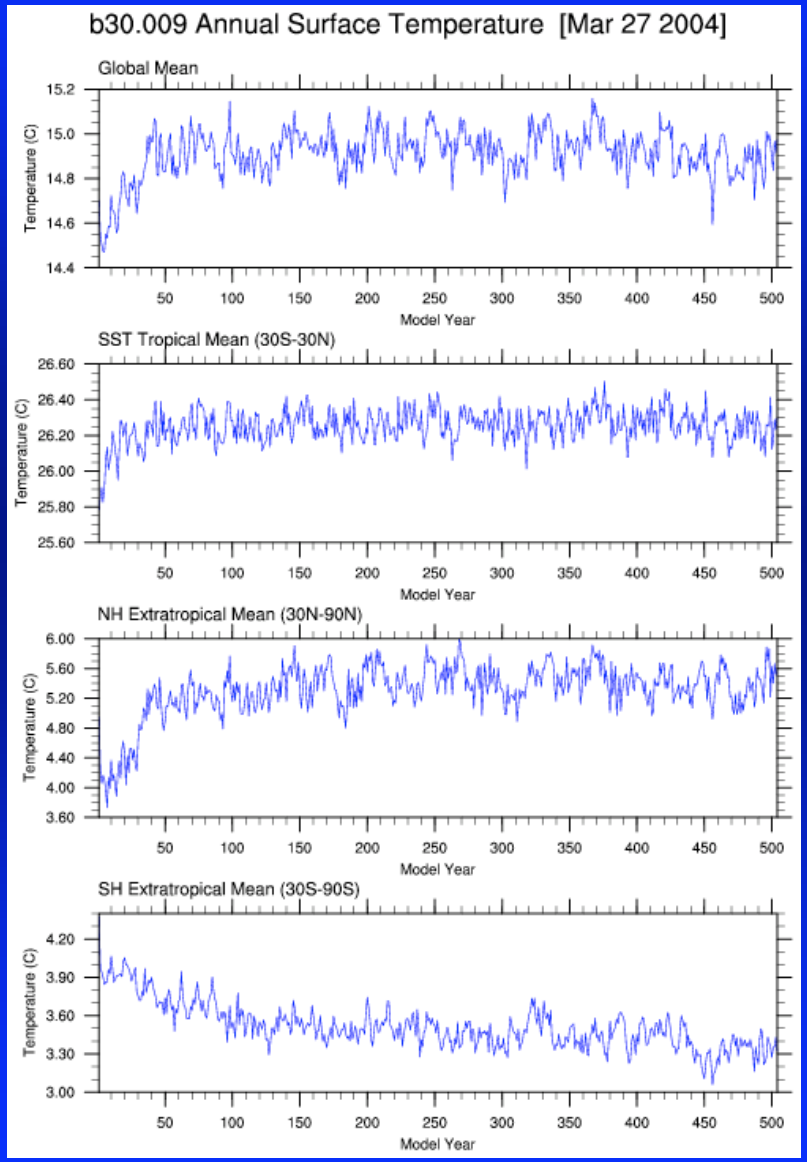


# Global Decrease in Surface Insolation

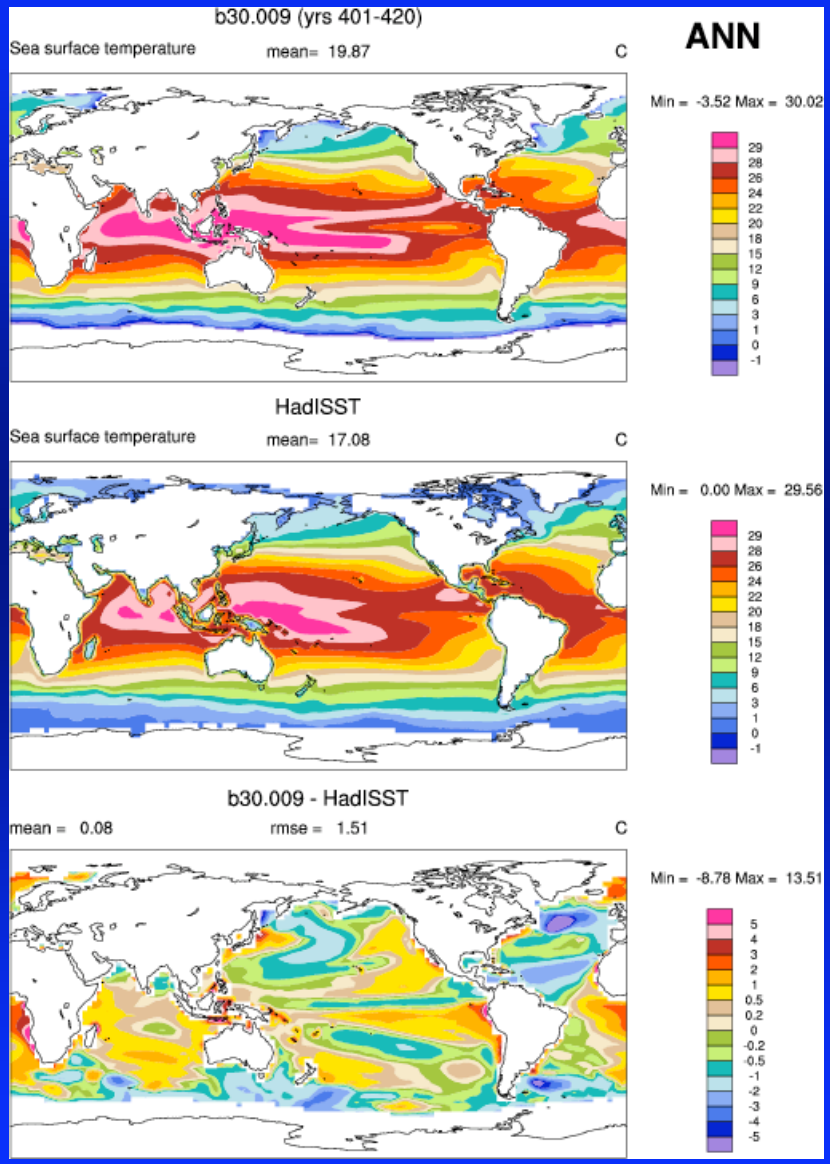


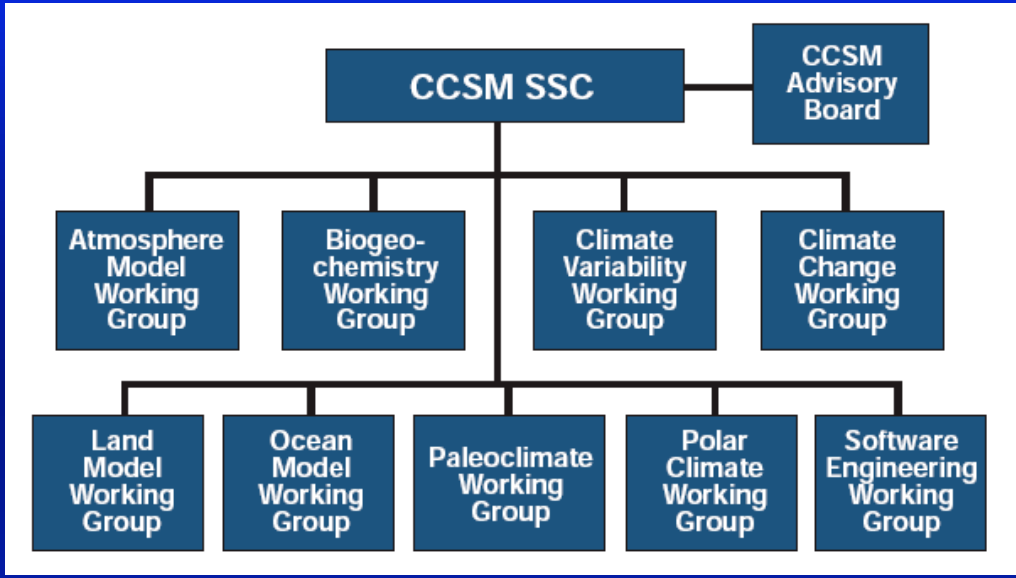
# Surface Temperatures: 1990 Integration

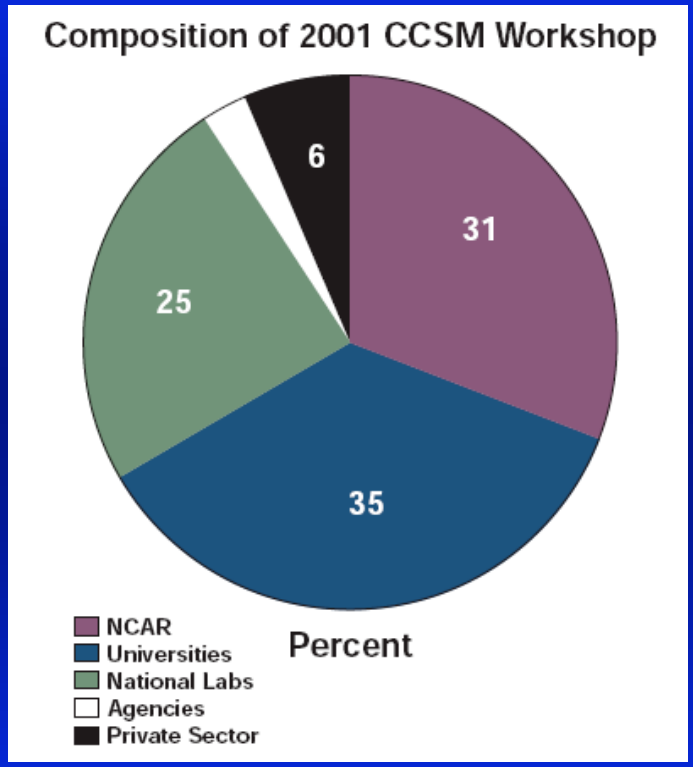


# Biases in Surface Temperatures



# Community Involvement in CCSM

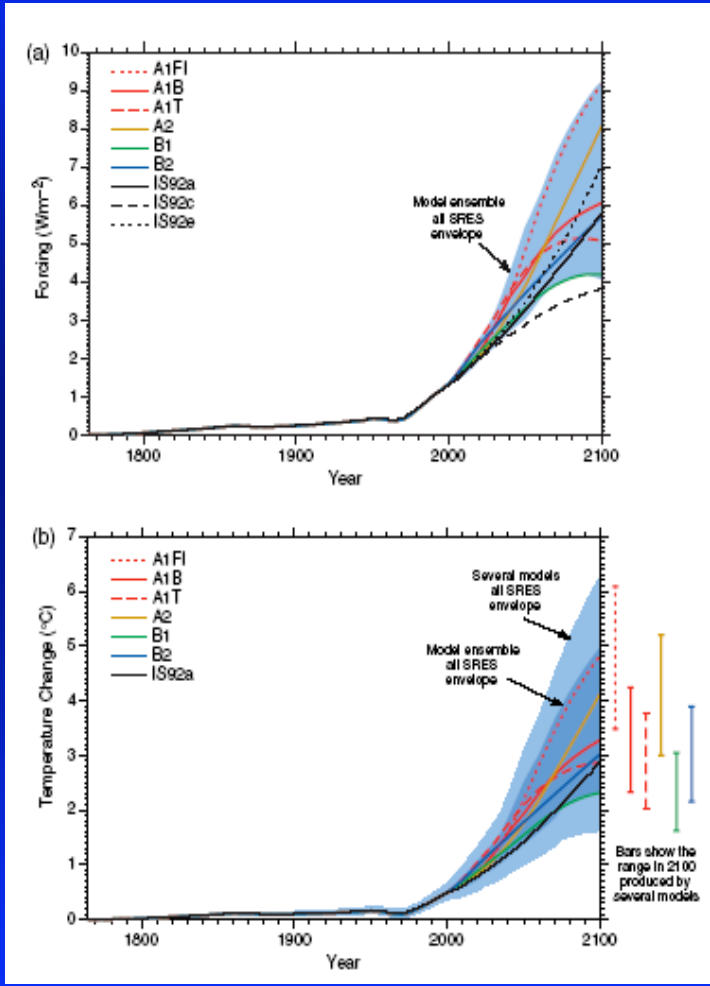



- CCSM3 public release: June 2, 2004
- Special *J. Climate* issue: Fall 2005

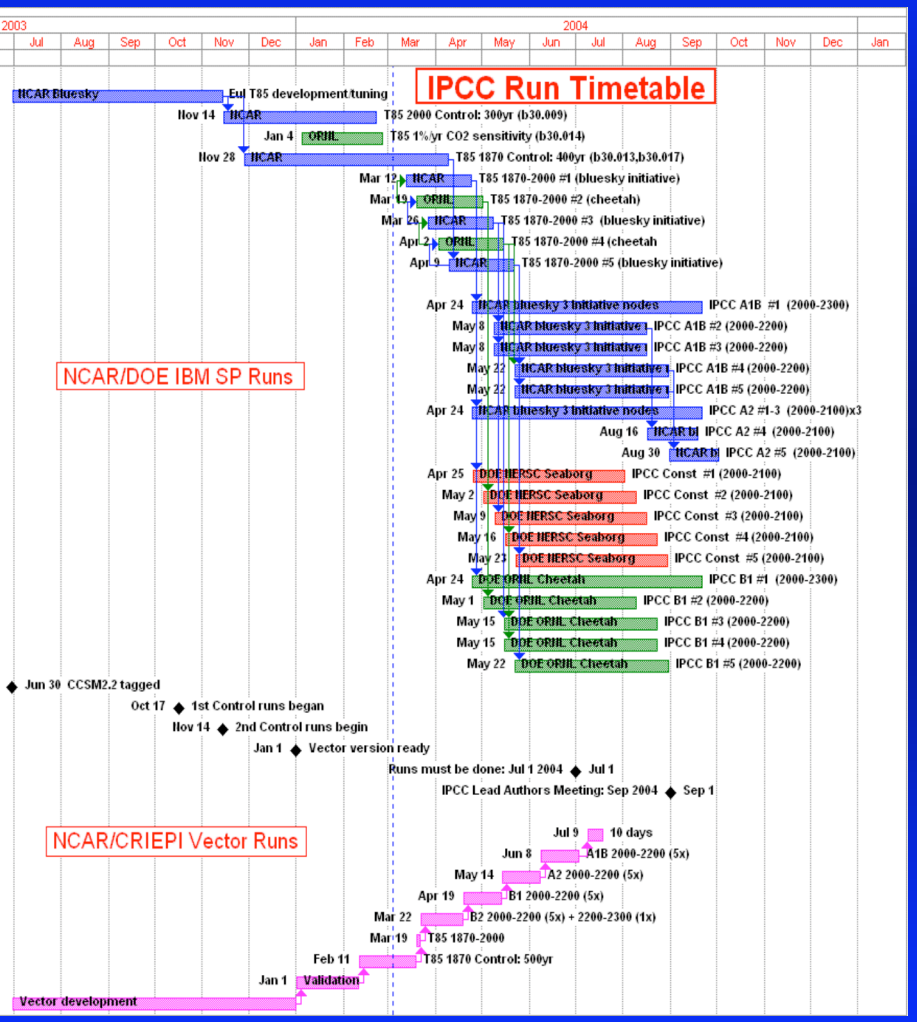
# The IPCC Integrations

- Three phases:
  1. Pre-industrial (1870)
  2. 20th Century (1870-2000)
  3. Emissions Scenarios (2000-2200)

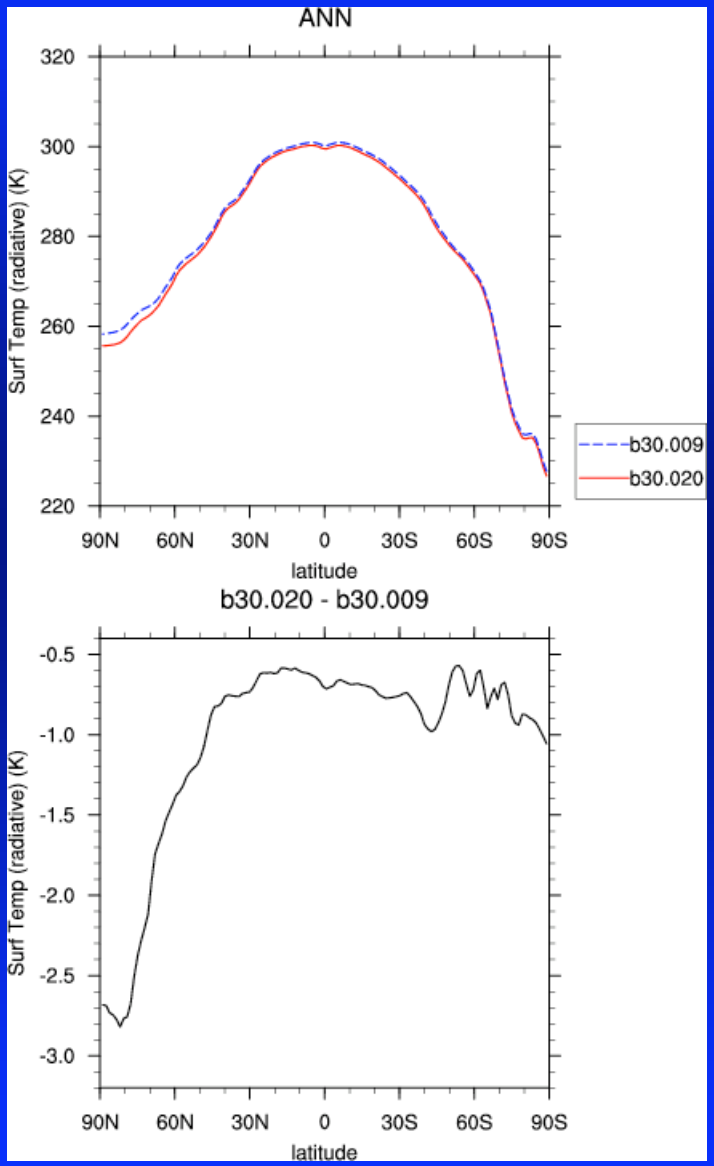


# Timeline for IPCC Integrations

| ID | Task Name | Resource Names |
|---|---|---|
| 1 | | |
| 2 | Eul T85 development/tuning | 4 yr/day on 192PEs |
| 3 | T85 2000 Control: 300yr (b30.009 | 4.5 yr/day on 192PEs |
| 4 | T85 1%/yr CO2 sensitivity (b30.0 | 4.5 yr/day on 192PEs |
| 5 | T85 1870 Control: 400yr (b30.013 | 3.3 yr/day on 192PEs |
| 6 | T85 1870-2000 #1 (bluesky initiati | 3.3 yr/day on 192PEs |
| 7 | T85 1870-2000 #2 (cheetah) | 3.3 yr/day on 192PEs |
| 8 | T85 1870-2000 #3 (bluesky initiat | 3.3 yr/day on 192PEs |
| 9 | T85 1870-2000 #4 (cheetah | 3.3 yr/day on 192PEs |
| 10 | T85 1870-2000 #5 (bluesky initiati | 3.3 yr/day on 192PEs |
| 11 | | |
| 12 | IPCC A1B #1 (2000-2300) | 2 yr/day on 96PEs |
| 13 | IPCC A1B #2 (2000-2200) | 2 yr/day on 96PEs |
| 14 | IPCC A1B #3 (2000-2200) | 2 yr/day on 96PEs |
| 15 | IPCC A1B #4 (2000-2200) | 2 yr/day on 96PEs |
| 16 | IPCC A1B #5 (2000-2200) | 2 yr/day on 96PEs |
| 17 | IPCC A2 #1-3 (2000-2100)x3 | 2 yr/day on 96PEs |
| 18 | IPCC A2 #4 (2000-2100) | 3.3 yr/day on 192PEs |
| 19 | IPCC A2 #5 (2000-2100) | 3.3 yr/day on 192PEs |
| 20 | IPCC Const #1 (2000-2100) | 1 yr/day on WH 96PEs |
| 21 | IPCC Const #2 (2000-2100) | 1 yr/day on WH 96PEs |
| 22 | IPCC Const #3 (2000-2100) | 1 yr/day on WH 96PEs |
| 23 | IPCC Const #4 (2000-2100) | 1 yr/day on WH 96PEs |
| 24 | IPCC Const #5 (2000-2100) | 1 yr/day on WH 96PEs |
| 25 | IPCC B1 #1 (2000-2300) | 2 yr/day on 96PEs |
| 26 | IPCC B1 #2 (2000-2200) | 2 yr/day on 96PEs |
| 27 | IPCC B1 #3 (2000-2200) | 2 yr/day on 96PEs |
| 28 | IPCC B1 #4 (2000-2200) | 2 yr/day on 96PEs |
| 29 | IPCC B1 #5 (2000-2200) | 2 yr/day on 96PEs |
| 30 | Jun 30 CCSM2.2 tagged | |
| 31 | 1st Control runs began | |
| 32 | 2nd Control runs begin | |
| 33 | Vector version ready | |
| 34 | Runs must be done: Jul 1 2004 | |
| 35 | IPCC Lead Authors Meeting: Sep 1 | |
| 36 | | |
| 37 | | analysis |
| 38 | A1B 2000-2200 (5x) | 40 yr/day[500%] |
| 39 | A2 2000-2200 (5x) | 40 yr/day[500%] |
| 40 | B1 2000-2200 (5x) | 40 yr/day[500%] |
| 41 | B2 2000-2200 (5x) + 2200-2300 ( | 40 yr/day[500%] |
| 42 | T85 1870-2000 | 40 yr/day[500%] |
| 43 | T85 1870 Control: 500yr | 40 yr/day[500%] |
| 44 | Validation | |
| 45 | Vector development | |



# Difference in Temperatures: 1870 - 1990



# Development Plans for CCSM, 2004-08


http://www.ccsm.ucar.edu/management/

# CCSM: The Next Two Years

- Roadmap to the future
  - Climate sensitivity from IPCC studies
  - Process studies from GFDL collaboration, CPTs
  - Studies of higher resolution and "benchmark" calculations
  - News physics/dynamics from Science Plan
- Integration of climate and chemistry
  - Ocean and land biogeochemistry
  - Prognostic aerosols
  - Tropospheric chemistry
  - Physical and chemical model of stratosphere-thermosphere
  - Isotopes of $H_2O$ and $CO_2$
  - Tracers

# The Evolution of CCSM